$\mathcal{H}_d$, $\mathcal{H}_{ex}$, $\mathcal{H}_{hfs}$ and the dipole-exchange interactions, respectively.

In conclusion, the author expresses his thanks to Prof. S. A. Al'tshuler for suggesting the topic and for his interest in the work.

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ON THE THEORY OF COMPOSITE π^0 MESONS

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Submitted to JETP editor April 4, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 508-509 (August, 1958)

IT is generally acknowledged today that the π mesons spend part of their time in the form of a baryon-antibaryon pair, i.e., the π mesons are represented at least part of the time (and in the model of Fermi and Yang,[1] all the time) as a tightly bound nucleon-antinucleon pair. If we require the π mesons to form an isotopic triplet, we obtain

$$\pi^+ = p\bar{n},\ \pi^0 = (p\bar{p} + n\bar{n})/\sqrt{2} = (\pi_1 + \pi_2)/\sqrt{2},\quad \pi^- = n\bar{p}. \tag{1}$$

Recently, the possibility also of the existence of an isotopic singlet was noted.[2,3] In the theory of composite particles this is represented as

$$\rho^0 = (p\bar{p} - n\bar{n})/\sqrt{2} = (\pi_1 - \pi_2)/\sqrt{2}. \tag{2}$$

Obviously, the Coulomb interaction in the $\pi_1 = p\bar{p}$ compound will result in different properties for the π_1 and π_2 mesons.

Following Zel' dovich,[4] it is easy to show that the masses of the π_1 and π_2 compounds are different:

$$\Delta M = m_{\pi_2} - m_{\pi_1} = c^{-2}\langle W_{\text{el-mag}}\rangle_{\text{av}} = (e/c)^2\langle -r^{-1}\rangle_{\text{av}} = 12.7\, m_e, \tag{3}$$

where m_e is the electron mass. The averaging is over the wave function found by Fermi and Yang.[1] It is clear that the life times of these compounds will also be different. Thus, according to the calculations of Romankevich, which use lowest-order perturbation theory,[5]

$$\tau(\pi_1)/\tau(\pi_2) = (3/\pi^2)(g^2/\hbar c)^2$$

($g^2/\hbar c$ is the dimensionless coupling constant for the coupling of the π meson field with the nucleons). Therefore, if initially the beam contains only π^0 mesons and if the corresponding wave function has the form $\Psi(0) = (\pi_1 + \pi_2)/\sqrt{2}$, then the amplitudes for the states π_1 and π_2 at time t will not be equal, and

$$\Psi(t) = \{\pi_1 \exp[-t/2\tau(\pi_1) + i\omega_1 t] + \pi_2 \exp[-t/2\tau(\pi_2) + i\omega_2 t]\}/\sqrt{2}, \tag{4}$$

where $\hbar\omega_i = c\sqrt{p^2 + m_i^2 c^2}$.

Thus it is possible that the relative phase of the states π_1 and π_2 changes, i.e., we have the possibility of the transition of the π^0 meson into a ρ^0 meson in real or, at least, virtual (when the mass of ρ^0 is greater than the mass of π^0) processes.

In the calculation of the probability for finding the π^0 or the ρ^0 mesons we can neglect the strongly oscillating term containing $\cos(c^2\Delta Mt/\hbar)$, since, according to (3), $c^2\Delta M/\hbar \sim 10^{-21}\ \text{sec}^{-1}$. Normalized for one particle, the probability for finding either meson has the form:

$$P(\pi^0 t) = P(\rho^0 t) = {}^1\!/_4\{\exp[-t/\tau(\pi_1)] + \exp[-t/\tau(\pi_2)]\},$$

i.e., our calculations lead to a decay scheme for the π^0 meson which is characterized by the sum of two exponentials.

Thus, according to the proposed scheme, π^0 and ρ^0 mesons participate in strong interactions, where the total isotopic spin is conserved, and π_1 and π_2 mesons participate in electromagnetic and weak interactions.

We do not exclude the possibility that the difference in the life times of the mesons emitted in different processes is connected with precisely this circumstance. For π^0 mesons produced in nucleon-nucleon collisions (strong interaction) $\tau \sim 5 \times 10^{-15}$ sec (reference 6), and for π^0 mesons arising in the K-meson decay (weak interaction), $\tau \lesssim 5 \times 10^{-16}$ sec (reference 7). According to our scheme, π^0 or ρ^0 mesons are emitted in the first case, and π_1 or π_2 mesons in the second case.

Obviously, this situation is entirely similar to that arising for neutral K mesons.[8]

In conclusion the author expresses his deep gratitude to V. V. Chavchanidze for his guidance.

Note added in proof (June 15, 1958): If we take, for example, $m_{\pi^+} \sim (\pi^+)^* Q\pi^+$, where Q is some "mass" operator, one can roughly estimate the mass of ρ^0 as ~ 139 Mev, using formulas (1) to (3). Hence, the investigation of π^0 production processes appears to be the most convenient way to discover the ρ^0 meson (cf. Fliagin, Dzhelepov, Kiselev, and Oganesian, Preprint R-188 Joint Inst. for Nucl. Prob.).

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Translated by R. Lipperheide
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SIMPLE MAGNETOACOUSTIC WAVES

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Submitted to JETP editor April 4, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 509 (August, 1958)

In ordinary hydrodynamics, it is shown[1] that points of high density in a simple wave move more rapidly than points with low density, if the inequality

$$\left(\frac{\partial^2}{\partial p^2}\frac{1}{\rho}\right) > 0 \qquad (1)$$

is satisfied.

In magnetic hydrodynamics, three types of simple waves are present:[2] fast and slow magnetoacoustic, and Alfven (magnetohydrodynamic) waves. The latter wave type is characterized by a constant density and constant velocity. As regards the first two types of waves, it can be shown that points of high density in them are displaced with higher velocity if condition (1) is satisfied.

It follows from this, in particular, that self-similar waves are always waves of discontinuity. The dependence of the phase velocity on the density leads, just as in ordinary hydrodynamics, to the result that in regions of compression the liquid continues to be compressed as long as a shock wave is not formed.

The authors thank A. I. Akhiezer and A. S. Kompaneits for valuable advice.

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Translated by R. T. Beyer
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IMPOSSIBILITY OF RAREFACTION SHOCK WAVES IN MAGNETOHYDRODYNAMICS

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Submitted to JETP editor April 4, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 510 (August, 1958)

As is known,[1] according to Zemplen's theorem in hydrodynamics, rarefaction shock waves are impossible if

$$\left(\frac{\partial^2}{\partial p^2}\frac{1}{\rho}\right)_s > 0 \qquad (1)$$

Landau and Lifshitz[2] have shown that in magnetohydrodynamic low-amplitude shock waves are compression waves if conditions (1) are satisfied.

Hoffmann and Teller[3] have shown that in an ideal gas the compressed shock wave is thermodynamic-